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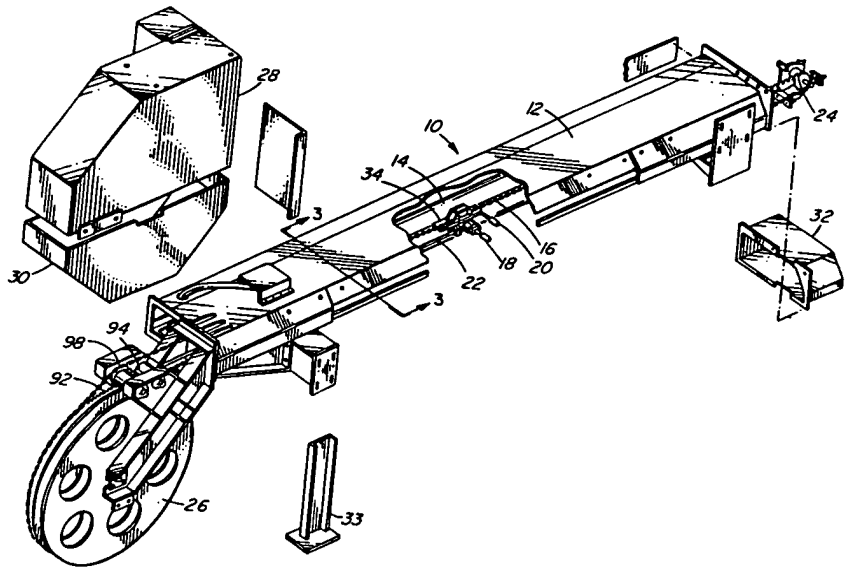

(57) Abstract

Apparatus (10) for controllably advancing a high pressure water jet (18) across a moving paper sheet to cut a tail therefrom. A hose (22) supplies pressurized water to the jet (18). A drive mechanism (14, 16, 92) advances the jet (18) and the hose (22) at the same rate across the paper sheet. The hose (22) is supported on a rotatable reel (26) during the advancing operation, in a manner which avoids the application of tension or compression forces to the hose (22) and prevents repeated flexing of the hose end at its connection to the high pressure water supply. A drive chain (16) is coupled between the jet (18) and the reel (26), whereby movement of the jet (18) causes corresponding movement of the chain (16), which causes corresponding movement of the reel (26), to uncoil or recoil the hose (22) at precisely the same rate as the jet (18) is advanced or retracted.

AN APPARATUS FOR CUTTING A MOVING PAPER SHEET BY MEANS OF A WATER JET

Field of the Invention

This application pertains to apparatus which controllably advances a high pressure water jet across a rapidly moving sheet of paper to cut a narrow tail along one side of the paper sheet and then gradually widens the cut, after the tail has been threaded through part of a paper making machine, to allow the full width of the paper sheet to be drawn through that part of the machine.

Background of the Invention

At various stages of the operation of a typical paper making machine a rapidly moving, continuous sheet of paper must be threaded through different parts of the machine as the paper is made. For example, one such stage occurs when the moving, continuous sheet of paper passes at high speed over a plurality of dryer rolls and then through a stack of calender rolls which calender the paper by imparting a finish of desired smoothness thereto. Since it is difficult to guide the full width of the moving paper sheet off the last dryer roll and then feed it through the calender stack, a narrow "tail" is cut to one side of the moving sheet as it comes off the last dryer roll, the balance of the moving sheet being allowed to fall into a broke pit for reprocessing. The tail is more easily fed through the calender stack and, once threaded, can be used to draw the full width of the paper sheet through the calender stack.

Those skilled in the art will readily appreciate that similar threading operations are encountered at other stages in the "dry end" operation of a typical paper making machine. These may for example involve passage of the moving paper sheet onto reel systems, slitters, winders, rewinders, or other parts of the paper making machine, as will be familiar to those skilled in the art. The present application focuses upon the calender stack threading operation by way of example only. It is to be understood

that the invention hereinafter disclosed may be applied to any tail threading operation encountered at the dry end of a paper making machine.

In the prior art, tails have been cut in light-weight paper by directing a blast of compressed air at the moving paper sheet. This however produces a torn, ragged edge which can be difficult to pass through the infeed nips of the calender roll stack. Paper tails have been produced in medium or heavier weight paper sheets by hand-tearing, which is a dangerous procedure that has resulted in serious operator injuries, and which also tends to produce a torn, ragged or folded edge.

Mechanical knives have more recently been employed to cut tails in rapidly moving paper sheets. However, mechanical knives are quickly dulled and lose their ability to cut the paper reliably and cleanly. This is particularly so if the knife is used to cut tough, hard stock such as a moving pulp sheet, which can be about 1/8" thick. If the knife is dull it tends to cut tails with a ragged edge, which are prone to tearing as they are manipulated during the calender stack threading operation.

Dulled knives can also fail to cut reliably on sheet break detection. Paper making machines employ sheet break sensors to detect and signal breakage of the moving paper sheet at points upstream from the dryer roll/calender stack interface. If the sheet breaks, then it must be cleanly severed ahead of the break and diverted into the broke pit to prevent the broken portion of the sheet from fouling the calender stack. Once the broken portion of the sheet has passed into the broke pit, and proper flow of the full width sheet over the dryer rolls has been reestablished, a new tail is cut, threaded through the calender stack, and then used to draw the unbroken sheet through the calender stack. On sheet break detection, the tail cutting

knife is rapidly drawn across the full width of the sheet with the object of cleanly severing the sheet as aforesaid. However, if the knife is dull, then it may fail to cut the sheet completely, cleanly, or at all. If the sheet is not cleanly severed, then portions of the sheet may overlap as the sheet enters the calender stack, causing "roll bounce", which may over time cause "barring", a form of marking of the calender rolls, which may eventually necessitate expensive, time-consuming resurfacing of the rolls and consequential downtime of the paper making equipment.

Mechanical knives have also been known to break, discharging metal pieces into the paper making equipment, which can result in serious damage to the equipment, again necessitating expensive, time-consuming repairs and consequential downtime of the paper making equipment.

The present invention employs a high pressure water jet to cut a tail in a rapidly moving paper sheet. The water jet is not dulled by the cutting operation, as is a mechanical knife.

Summary of the Invention

In accordance with the preferred embodiment, the invention provides apparatus for controllably advancing a high pressure water jet across a moving paper sheet to cut a tail therefrom. The apparatus comprises a hose for supplying pressurized water to the jet, drive means for advancing the jet and the hose at the same rate across the paper sheet, and hose support means for supporting the hose during the advancing operation, without applying tension or compression forces to the hose.

The hose support means preferably comprises a rotatable reel for coilingly receiving the hose. The drive means preferably comprises a chain coupled between the jet and the reel, whereby movement of the jet causes correspon-

ding movement of the chain, which causes corresponding movement of the reel. The chain is coupled to the reel by a first sprocket coaxially aligned with the reel. The first sprocket has the same pitch diameter as the hose, when the hose lies coiled around the reel.

Advantageously, the drive means further comprises a linear cylinder having a slidably displaceable piston. The jet and the chain are coupled to the piston for slidable displacement therewith.

An idler sprocket is advantageously provided. Preferably, the first sprocket and the reel are disposed at one end of the cylinder, the idler sprocket is disposed at the opposite end of the cylinder, and the chain traverses an endless loop from the piston, around the first sprocket, and around the idler sprocket, returning to the piston. The idler sprocket is preferably mounted for adjustable positioning thereof, thereby facilitating adjustment of the tension on the chain.

Hose guiding means are provided for guiding the hose onto the reel in horizontally spaced coils and for preventing vertical stacking of the coils. The hose guiding means may comprise a tapered roller disposed between the reel and the jet, adjacent the reel, with the lower surface of the tapered roller aligned slightly below the upper surface of the reel.

The reel is supported on a rotatable axle. Pressurized water coupling means are provided for supplying pressurized water through the axle to the hose. The pressurized water coupling means comprises a first high pressure conduit having first and second ends; a channel in the axle for receiving the first conduit such that the first conduit first end protrudes longitudinally from one end of the axle and the first conduit second end protrudes

transversely from the central region of the axle; rotatable coupling means for rotatably coupling the first conduit first end to a source of pressurized water; and, hose coupling means for coupling the first conduit second end to the hose. Advantageously, the hose coupling means further comprises a second high pressure conduit extending from the first conduit second end toward the circumference of the reel, thereby increasing the radius through which the hose bends for coupling to the first conduit second end. This prevents repeated flexing of the hose end at its point of connection to the source of pressurized water.

A chain position sensing means is provided for sensing the position of a reference point on the chain and for producing an output signal representative of that position. The chain position sensing means may comprise a third sprocket drivingly engageable by the chain, and a shaft encoder coupled to the third sprocket for producing an output signal proportional to the number of revolutions of the third sprocket. Reset means may be provided for resetting the output signal to a preselected value whenever the reference point coincides with a normally inactive storage position of the jet. The reset means may comprise a proximity switch for detecting movement of the jet into the storage position and for producing an output signal representative thereof. The reset means may also interrupt the supply of pressurized water to the jet whenever the jet is in its storage position.

Power fail detector means may be provided for interrupting the supply of pressurized water to the jet and for moving the jet into the normally inactive storage position upon reconnection of electrical power to the apparatus following disconnection of power therefrom.

A splitter jet may be provided to controllably, intermittently direct a high pressure water jet toward the

central region of the paper sheet which falls into the broke pit.

Brief Description of the Drawings

Figure 1 is a partially fragmented, partially exploded perspective illustration of a high pressure water jet paper tail cutter constructed in accordance with the preferred embodiment of the invention.

Figure 2 is a perspective illustration of the rear side of the hose reel portion of the apparatus depicted in Figure 1.

Figure 3 is a cross-sectional illustration taken with respect to the line 3-3 of Figure 1.

Figure 4 is a partially fragmented, exploded pictorial illustration of the fixed, high pressure water "splitter" jet of the preferred embodiment.

Figure 5 is an exploded pictorial illustration of the rodless linear air cylinder and movable tail cutter jet of the preferred embodiment.

Figure 6 is a rear elevation view of the hose reel portion of the apparatus depicted in Figure 1; most of the high pressure water supply circuitry having been omitted from Figure 6.

Figure 7 is a cross-sectional illustration taken with respect to the line 7-7 of Figure 6.

Figure 8 is a cross-sectional illustration taken with respect to the line 8-8 of Figure 6.

Figure 9 is a right end elevation view of the hose reel depicted in Figure 6.

Figure 10 is a rear elevation view of the portion of the high pressure water supply manifold circuitry of the preferred embodiment.

Figure 11 is a cross-sectional illustration taken with respect to the line 11-11 of Figure 10.

Figure 12 is a partially fragmented rear elevation view of a portion of the hose reel of the preferred embodiment, showing the coupling of the high pressure water supply to the hose.

Figure 13 is a right end elevation view of the hose reel depicted in Figure 12.

Figure 14 is a top plan view of the hose reel axle of the preferred embodiment.

Figure 15 is a simplified pictorial illustration depicting a full width moving paper sheet passing off the last of a sequence of dryer rolls, over a high pressure water jet paper tail cutter constructed in accordance with the preferred embodiment of the invention, and onto the first of a stack of calender rolls. Figure 15 depicts the high pressure water jet paper tail cutter in its inactive state.

Figure 16 depicts the tail cutter jet being drawn across the paper sheet to sever the sheet, which then falls into a broke pit. Figure 16 also shows the splitter jet splitting the severed sheet as it falls into the broke pit.

Figure 17 depicts the full width sheet falling into the broke pit, while being split by the splitter jet.

Figure 18 depicts the tail cutter jet cutting a tail along one side of the moving paper sheet for threading through the calender stack.

Figure 19 depicts the tail cutter jet being drawn across the moving paper sheet, toward the splitter jet, to widen the segment of the paper sheet which is drawn through the calender stack by the threaded tail.

Figure 20 depicts tail cutter jet being drawn across the moving paper sheet, past the now inoperative splitter jet, to further widen the segment of the paper sheet which is drawn through the calender stack.

Figure 21 depicts the high pressure water jet paper tail cutter returned to its inactive state, with the full width moving paper sheet being drawn into the calender stack and the end of the severed sheet falling into the broke pit.

Detailed Description of the Preferred Embodiment

Figure 1 depicts a high pressure water jet paper tail cutter apparatus generally designated 10. Apparatus 10 incorporates an elongate air-pressurized housing 12, which encloses cylinder 14, extended upper and lower portions of drive chain 16, movable tail cutter jet 18, fixed splitter jet 20, a portion of hose 22 and idler sprocket 24. Tail cutter jet 18 and hose 22 are controllably slidably displaceable along cylinder 14, as hereinafter explained. During such displacement, hose 22 is supported by reel 26 in a manner which avoids the application of tension or compression forces to hose 22 and which prevents repeated flexing of the hose end at its point of connection to the high pressure water supply. Shrouds 28, 30 normally cover reel 26, preventing foreign substances from fouling chain 16, hose 22 or reel 26. Similarly, shroud 32 normally encloses idler 24 at the opposite end of

housing 12. Apparatus 10 is supported at an appropriate height on stanchions 33 (only one of which is shown).

Cylinder 14 is preferably an **ORIGA**™ rodless linear pneumatic cylinder available from Origa Corporation of Elmhurst, Illinois. Cylinder 14 is sized to extend longitudinally through housing 12 such that the range of slidable displacement of slider block 34 coupled to the slidably displaceable piston (not shown) of cylinder 14 exceeds the full width of the paper sheet with which apparatus 10 is to be utilized. As best seen in Figures 3 and 5, movable tail cutter jet 18 is directly coupled to slider block 34 via carriage 36. The high pressure water delivery end of hose 22 is also coupled to slider block 34 via carriage 36. More particularly, a pair of split blocks 38, 40 clamp the end of hose 22. Blocks 38, 40 are bolted to the front face of carriage 36, which is in turned bolted to the underside of slider block 34. An elbow connector 42 conveys pressurized water from hose 22 into conduit 44, which is clamped between split blocks 46 by bolts passed through blocks 46 into arm 48 which projects forwardly from the front face of carriage 36. Conduit 44 conveys pressurized water to tail cutter jet 18, which emits water pressurized to about 20,000 p.s.i. through a .005" diameter orifice.

Bolts 50, 52 which fasten carriage 36 to the underside of slider block 34 also fasten chain connector plate 54 to the upper surface of slider block 34. Chain connector 56 is in turn bolted to chain connector plate 54. The opposed ends of chain 16 are coupled together by chain connector 56 to form an endless loop chain, as hereinafter explained.

Cylinder 14 is supported within housing 12 on pad 58 and held in place by clamps 60, 62; end brackets 64, 66 and pads 68, 70, 72, 74.

As best seen in Figures 3 and 4, splitter jet 20 is fixed within housing 12 at about the midpoint thereof. Rigid high pressure conduit 76 conveys pressurized water from elbow connector 78 to elbow connector 80, which in turn supplies jet 20 through conduit 82. Clamps 84 attach conduit 76 at intervals to mounting rail 86, which is suspended from the internal, upper surface of housing 12, as shown in Figure 3. Conduit 82 is held in position by stop bracket 88, which is also connected to the internal, upper surface of housing 12, as shown in Figure 3.

Hose 22 is preferably a **SPIR-STAR**™ super high pressure hose available from D&G Industries, Inc. of Holbrook, New York. As best seen in Figures 1, 2, 6, 9 and 12, the portion of hose 22 which does not extend within housing 12 is coiled upon reel 26 which rotates about axle 90 (Figures 9, 13 and 14). Care must be taken to avoid subjecting hose 22 to tension or compression forces, and to prevent repeated flexing of the hose ends, as hose 22 is paid out from or taken up on reel 26 during slidable advance or retraction of tail cutter jet 18 along cylinder 14. The application of tension or compression forces to hose 22 is avoided, in the preferred embodiment, by entraining chain 16 around a first sprocket 92 coaxial with axle 90. Sprocket 92 has the same pitch diameter as hose 22 when hose 22 lies coiled around reel 26. As best seen in Figure 9, the pitch diameter of sprocket 92 equals pitch diameter of hose 22 when hose 22 is coiled upon reel 26. The "drive means" comprising cylinder 14, drive chain 16 and sprocket 92 thus advances or retracts hose 22 at the same rate as tail cutter jet 18.

It is also important to ensure that hose 22 is guided onto reel 26 in horizontally spaced coils in a manner which prevents vertical stacking of the coils. If the hose coils became vertically stacked one above the

other, then hose 22 would no longer have the same pitch diameter as sprocket 92. This would in turn allow hose 22 to be paid out from or taken up on reel 26 at a speed which differed from the speed at which tail cutter jet 18 was advanced or retracted along cylinder 14, subjecting hose 22 to potentially damaging tension or compression forces. Accordingly, "hose guiding means"; namely, tapered roller 94 are provided for guiding hose 22 onto reel 26 in controlled fashion. As may be seen in Figures 6 and 7, tapered roller 94 is disposed between reel 26 and jet 18, adjacent reel 26, with lower surface 96 of roller 94 aligned slightly below the upper surface of reel 26. As reel 26 rotates clockwise (as viewed in Figure 6) roller 94 guides hose 22 onto reel 26 in a single layer of horizontally spaced coils as shown in Figure 7, while preventing vertical stacking of the coils. Sprocket 98 (Figures 1, 6 and 9) elevates chain 16 so that it clears roller 94.

Shaft encoder 100 (Figures 2, 6 and 8) serves as a "chain position sensing means" for sensing the position of a reference point on chain 16 (i.e. the position of the mid point of chain connector 56, which is in turn representative of the position of the high pressure water jet orifice of tail cutter jet 18) and for producing an output signal representative of that position. Sprocket 102 is drivingly engaged by the lower section of chain 16 as it emerges from elongate housing 12 to engage sprocket 92. Shaft encoder 100 is drivingly coupled to sprocket 102 and produces an output signal proportional to the number of revolutions of sprocket 102.

A "reset means" such as magnetic proximity switch (not shown) may be provided for resetting the output signal produced by encoder 100 to a preselected value (i.e. zero) whenever the proximity switch detects movement of the reference point aforesaid to coincide with a normally inactive storage position of tail cutter jet 18. This

eliminates slight errors in the position signal output by encoder 100 which could otherwise accumulate over time to produce an erroneous indication of the position of jet 18. Actuation of the reset means by movement of jet 18 to its storage position also preferably interrupts the supply of pressurized water to jet 18. An electronic power fail detector means may also be provided to interrupt the supply of pressurized water to jet 18 and to actuate apparatus 10 to move jet 18 into its normally inactive storage position whenever electrical power is reconnected to apparatus 10 following disconnection of electrical power therefrom. This ensures that jet 18 is not activated in circumstances in which the position of jet 18, or the operational state of other components incorporated in apparatus 10, may be unknown.

Chain 16 traverses an endless loop. More particularly, one end of chain 16 is coupled to chain connector 56 as aforesaid. Chain 16 passes from connector 56 around idler sprocket 24 and then returns underneath connector 56 to pass over sprocket 102, and thence over sprockets 92 and 98, from which it returns to couple, at its opposite end, to connector 56. Idler sprocket 24 is mounted at the end of housing 12 in such a manner it may be adjustably slidably displaced in order to regulate the tension on drive chain 16. This location of the chain tensioning mechanism facilitates concurrent adjustment of the upper and lower lengths of chain which pass through housing 12.

Pressurized water is supplied to hose 22 by a waterjet intensifier (not shown) such as the **STREAMLINE**™ model 25S, 40S or 50S intensifiers available from Ingersoll-Rand of Baxter Springs, Kansas. These devices are capable of supplying water pressurized to between 12,000 and 55,000 p.s.i. A water pressure of about 20,000 p.s.i. has been found suitable for operation of apparatus 10.

Pressurized water supplied by the waterjet intensifier enters via conduit 104 (Figures 2 and 10) and passes through stem valve 106, conduit 108, elbow 110, conduit 112, and filter 114 to cross connector 116. Cross connector 116 diverts a portion of the pressurized water flow through conduit 118 and control valve 120 into conduit 122 which is coupled to rigid high pressure conduit 76 and thence to splitter jet 20. Cross connector 116 diverts the other portion of the pressurized water flow through conduit 124, control valve 126, conduit 128, and swivel connector 130 to coupler 132 (Figure 11) for delivery to hose 22.

A "pressurized water coupling means"; namely, first high pressure conduit 134 (Figure 13) delivers the pressurized water from coupler 132 through hose reel axle 90 to hose 22, as will now be described with reference to Figures 12, 13 and 14. First high pressure conduit 134 has a first end 136 and a second end 138. A channel is cut in axle 90 to receive conduit 134 such that conduit first end 136 protrudes longitudinally from one end of axle 90 and conduit second end 138 protrudes transversely from the central region of axle 90. Swivel connector 130 (Figures 9, 10 and 11) serves as a "rotatable coupling means" for rotatably coupling conduit first end 136 to the source of pressurized water while accommodating rotational movement of reel 26, axle 90 and first high pressure conduit 134.

A "hose coupling means"; namely, second high pressure conduit 140 couples first conduit second end 138 to hose 22 through elbow 142. As may be seen in Figures 12 and 13, second high pressure conduit 140 extends from first conduit second end 138 toward the circumference of reel 26, thereby increasing the radius through which hose 22 bends for coupling to first conduit second end 138. This is important to avoid imposing undesirable stresses on the end of hose 22 by repeatedly flexing the hose end through a small radius. Hose 22 is clamped to one internal side of

reel 26 by clamp 144 and passes through reel aperture 146 onto the circumferential hose winding surface 148 of reel 26.

The operation of the preferred embodiment will now be described with reference to Figures 15 through 21. Figure 15 is a simplified pictorial illustration depicting a full width moving paper sheet 200 passing off the last roller 202 of a sequence of dryer rolls, over apparatus 10, and onto the first roll 204 of a stack of calender rolls. Figure 15 depicts apparatus 10 in its inactive state in which no pressurized water flows to tail cutter jet 18 or to splitter jet 20, and in which tail cutter jet 18 remains stationary in its normally inactive storage position off to one side of paper sheet 200.

Figure 16 depicts tail cutter jet 18 being drawn across paper sheet 200, while emitting a high pressure water jet stream, thereby severing sheet 200 along an angular line 206 determined by the relative speeds of tail cutter jet 18 and paper sheet 200. The severed end 208 of sheet 200 falls into a broke pit, carrying the balance of sheet 200 with it. It will be noted that jet 18 may be actuated to emit a high pressure water jet stream even before jet 18 is drawn across sheet 200. This is to be contrasted with prior art mechanical cutters, which cannot be advanced from a point off to one side of the moving paper sheet into the edge of the sheet without breaking the sheet. Prior art mechanical cutters must be plunged into a central portion of the moving paper sheet and then drawn to each edge of the sheet to sever it. However, jet 18 severs sheet 200 by traversing a single pass from one side of the sheet to the other. Figure 16 also depicts actuation of splitter jet 20 which splits severed sheet 208, as shown at 210, by directing a high pressure water jet stream at severed sheet 208 as it falls into the broke pit. This

breaks up the severed sheet, making it somewhat easier to reprocess.

In Figure 17, tail cutter jet 18 has completely severed sheet 200 and is positioned at rest (i.e. the supply of pressurized water to jet 18 has been turned off) to the opposite side of the paper sheet. The full width of sheet 200 falls into the broke pit, while being split by the splitter jet 20 for reprocessing.

Figure 18 depicts tail cutter jet 18 positioned inwardly about 4" to 6" from the edge of paper sheet 200 and actuated to cut a tail 212 along one side of the moving paper sheet for threading through the calender stack. The balance of sheet 200 continues to fall into the broke pit, while being split by splitter jet 20.

Figure 19 depicts the widening of tail 212, after successful threading of the initial narrow tail through the calender stack. This is accomplished by continuing the emission of a high pressure water jet stream from tail cutter jet 18, while drawing tail cutter jet 18 across moving paper sheet 200, toward splitter jet 20, to widen the segment of the paper sheet drawn through the calender stack by the previously threaded portion of tail 212. As depicted in Figure 19, splitter jet 20 is deactivated just before tail cutter jet 18 passes beneath splitter jet 20.

Figure 20 depicts the continued drawing of tail cutter jet 18 across moving paper sheet 200, past now inoperative splitter jet 20, to further widen the segment 212 of paper sheet 200 which is drawn through the calender stack.

Figure 21 depicts apparatus 10 returned to its inactive state, with the full width moving paper sheet 200 being drawn into the calender stack and the end of severed

sheet 208 falling into the broke pit. Tail cutter jet 18 has returned to its normally inactive storage position and its source of pressurized water has been turned off.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. For example, the various sprockets could be replaced with rollers or sheaves. Drive chain 16 could be replaced with a cable wound around a drum to yield the same pitch diameter as hose 22 coiled upon reel 26. Either or both of sprockets 24, 92 could be replaced by controllable drive mechanisms, which would obviate the need for cylinder 14 while still facilitating travel of hose 22 at the same rate as tail cutter jet 18, without subjecting hose 22 to tension or compression forces, or to repeated flexing of the hose ends. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

WHAT IS CLAIMED IS:

1. Apparatus for controllably advancing, across a moving paper sheet, a high pressure water jet and a hose which supplies pressurized water to the jet, thereby to cut a tail from said paper sheet, said apparatus characterized by:
   (a) drive means for advancing said jet and said hose at the same rate across said paper sheet; and,
   (b) hose support means for supporting said hose during said advancing operation, without applying tension or compression forces to said hose.

2. Apparatus for controllably advancing a high pressure water jet across a moving paper sheet to cut a tail therefrom, said apparatus comprising:
   (a) a hose for supplying pressurized water to said jet;
   (b) drive means for advancing said jet and said hose at the same rate across said paper sheet; and,
   (c) hose support means for supporting said hose during said advancing operation, without applying tension or compression forces to said hose.

3. Apparatus as defined in claim 2, wherein:
   (a) said hose support means comprises a rotatable reel for coilingly receiving said hose; and,
   (b) said drive means comprises a chain coupled between said jet and said reel;
   whereby movement of said jet causes corresponding movement of said chain, which causes corresponding movement of said reel.

4. Apparatus as defined in claim 2, wherein:
   (a) said hose support means comprises a rotatable reel for coilingly receiving said hose; and,

(b) said drive means comprises a cable coupled between said jet and said reel;

whereby movement of said jet causes corresponding movement of said cable, which causes corresponding movement of said reel.

5. Apparatus as defined in claim 3, wherein:

(a) said chain is coupled to said reel by a first sprocket coaxially aligned with said reel; and,

(b) said first sprocket has the same pitch diameter as said hose, when said hose lies coiled around said reel.

6. Apparatus as defined in claim 4, wherein said cable is coupled to said reel by winding said cable around a drum connected to said reel to give said wound cable an effective pitch diameter equal to the pitch diameter of said hose, when said hose lies coiled around said reel.

7. Apparatus as defined in claim 5, wherein:

(a) said drive means further comprises a linear cylinder having a slidably displaceable piston; and,

(b) said jet and said chain are coupled to said piston for slidable displacement therewith.

8. Apparatus as defined in claim 6, wherein:

(a) said drive means further comprises a linear cylinder having a slidably displaceable piston; and,

(b) said jet and said cable are coupled to said piston for slidable displacement therewith.

9. Apparatus as defined in claim 7, further comprising an idler sprocket, and wherein:

(a) said first sprocket and said reel are disposed at one end of said cylinder;

(b) said idler sprocket is disposed at the opposite end of said cylinder; and,

(c) said chain traverses an endless loop from said piston, around said first sprocket, and around said idler sprocket, to said piston.

10. Apparatus as defined in claim 8, further comprising an idler roller, and wherein:

(a) said reel and said drum are disposed at one end of said cylinder;

(b) said idler roller is disposed at the opposite end of said cylinder; and,

(c) said cable traverses an endless loop from said piston, around said drum, and around said idler roller, to said piston.

11. Apparatus as defined in claim 9, wherein said idler sprocket is mounted for adjustable positioning thereof, thereby facilitating adjustment of said chain tension.

12. Apparatus as defined in claim 10, wherein said idler roller is mounted for adjustable positioning thereof, thereby facilitating adjustment of said chain tension.

13. Apparatus as defined in claim 3 or 4, further comprising hose guiding means for guiding said hose onto said reel in horizontally spaced coils and for preventing vertical stacking of said coils.

14. Apparatus as defined in claim 3 or 4, further comprising hose guiding means for guiding said hose onto said reel in horizontally spaced coils and for preventing vertical stacking of said coils, said hose guiding means comprising a tapered roller disposed between

said reel and said jet, adjacent said reel, with the lower surface of said tapered roller aligned slightly below the upper surface of said reel.

15. Apparatus as defined in claim 3 or 4, wherein said reel is supported on a rotatable axle, said apparatus further comprising pressurized water coupling means for supplying said pressurized water through said axle to said hose.

16. Apparatus as defined in claim 3 or 4, wherein said reel is supported on a rotatable axle, said apparatus further comprising:

(a) a first high pressure conduit having first and second ends;

(b) an channel in said axle for receiving said first conduit such that said first conduit first end protrudes longitudinally from one end of said axle and said first conduit second end protrudes transversely from the central region of said axle;

(c) rotatable coupling means for rotatably coupling said first conduit first end to a source of pressurized water; and,

(d) hose coupling means for coupling said first conduit second end to said hose.

17. Apparatus as defined in claim 3 or 4, wherein said reel is supported on a rotatable axle, said apparatus further comprising:

(a) a first high pressure conduit having first and second ends;

(b) an channel in said axle for receiving said first conduit such that said first conduit first end protrudes longitudinally from one end of said axle and said first conduit second end protrudes

transversely from the central region of said axle;

(c) rotatable coupling means for rotatably coupling said first conduit first end to a source of pressurized water; and,

(d) a second high pressure conduit extending from said first conduit second end toward the circumference of said reel, thereby increasing the radius through which said hose bends for coupling to said first conduit second end.

18. Apparatus as defined in claim 3, further comprising chain position sensing means for sensing the position of a reference point on said chain and for producing an output signal representative of said position.

19. Apparatus as defined in claim 4, further comprising cable position sensing means for sensing the position of a reference point on said cable and for producing an output signal representative of said position.

20. Apparatus as defined in claim 18, wherein said chain position sensing means comprises:

(a) a third sprocket drivingly engageable by said chain; and,

(b) a shaft encoder coupled to said third sprocket for producing an output signal proportional to the number of revolutions of said third sprocket.

21. Apparatus as defined in claim 19, wherein said chain position sensing means comprises:

(a) a sheave drivingly engageable by said cable; and,

(b) a shaft encoder coupled to said sheave for producing an output signal proportional to the number of revolutions of said sheave.

22. Apparatus as defined in claim 18 or 19, further comprising reset means for resetting said output signal to a preselected value whenever said reference point coincides with a normally inactive storage position of said jet.

23. Apparatus as defined in claim 18 or 19, further comprising reset means for resetting said output signal to a preselected value whenever said reference point coincides with a normally inactive storage position of said jet, wherein said reset means comprises a proximity switch for detecting movement of said jet into said storage position and for producing a reset signal representative thereof.

24. Apparatus as defined in claim 18 or 19, further comprising reset means for interrupting the supply of pressurized water to said jet whenever said reference point coincides with a normally inactive storage position of said jet.

25. Apparatus as defined in claim 18 or 19, further comprising reset means for interrupting the supply of pressurized water to said jet whenever said reference point coincides with a normally inactive storage position of said jet, wherein said reset means comprises a proximity switch for detecting movement of said jet into said storage position and for producing an output signal representative thereof.

26. Apparatus as defined in claim 3 or 4, further comprising power fail detector means for interrupting the supply of pressurized water to said jet and for moving said jet into a normally inactive storage position upon reconnection of electrical power to said apparatus following disconnection of power therefrom.

27. Apparatus as defined in claim 3 or 4, further comprising a splitter jet fixed for controllable, intermittent direction of a high pressure water jet toward the central region of said paper sheet.

AMENDED CLAIMS

[received by the International Bureau on 22 January 1991 (22.01.91) ; original claims 1, 5 and 6 amended ; new claims 28 and 29 added ; other claims unchanged (3 pages)]

1. Apparatus for controllably advancing, across a moving paper sheet, a high pressure water jet and a hose which supplies pressurized water to the jet, thereby to cut a tail from said paper sheet, said apparatus having drive means for advancing and retracting said jet and said hose at the same rate across said paper sheet and hose support means for supporting said hose during said advancing and retracting operations, characterized in that the hose is advanced and retracted without applying tension or compression forces to said hose.

2. Apparatus for controllably advancing a high pressure water jet across a moving paper sheet to cut a tail therefrom, said apparatus comprising:
   (a) a hose for supplying pressurized water to said jet;
   (b) drive means for advancing said jet and said hose at the same rate across said paper sheet; and,
   (c) hose support means for supporting said hose during said advancing operation, without applying tension or compression forces to said hose.

3. Apparatus as defined in claim 2, wherein:
   (a) said hose support means comprises a rotatable reel for coilingly receiving said hose; and,
   (b) said drive means comprises a chain coupled between said jet and said reel;
   whereby movement of said jet causes corresponding movement of said chain, which causes corresponding movement of said reel.

4. Apparatus as defined in claim 2, wherein:
   (a) said hose support means comprises a rotatable reel for coilingly receiving said hose; and,

(b) said drive means comprises a cable coupled between said jet and said reel;

whereby movement of said jet causes corresponding movement of said cable, which causes corresponding movement of said reel.,

5. Apparatus as defined in claim 2, wherein:

(a) said chain is coupled to said reel by a first sprocket coaxially aligned with said reel; and,

(b) said first sprocket has the same pitch diameter as said hose, when said hose lies fully retracted and coiled around said reel.

6. Apparatus as defined in claim 4, wherein said cable is coupled to said reel by winding said cable around a drum connected to said reel to give said wound cable an effective pitch diameter equal to the pitch diameter of said hose, when said hose lies fully retracted and coiled around said reel.

7. Apparatus as defined in claim 5, wherein:

(a) said drive means further comprises a linear cylinder having a slidably displaceable piston; and,

(b) said jet and said chain are coupled to said piston for slidable displacement therewith.

8. Apparatus as defined in claim 6, wherein:

(a) said drive means further comprises a linear cylinder having a slidably displaceable piston; and,

(b) said jet and said cable are coupled to said piston for slidable displacement therewith.

9. Apparatus as defined in claim 7, further comprising an idler sprocket, and wherein:

27. Apparatus as defined in claim 3 or 4, further comprising a splitter jet fixed for controllable, intermittent direction of a high pressure water jet toward the central region of said paper sheet.

28. Apparatus for controllably advancing, across a moving sheet of material such as paper, a high pressure water jet and a hose which supplies pressurized water to the jet, thereby to cut a tail from said sheet, said apparatus having drive means for advancing and retracting the jet and the hose together across the sheet, and hose support means for supporting the hose during the advancing and retracting operations; characterized by a mechanical linkage between the drive means and the hose support means that bears the forces of tension or compression associated with such advancing and retracting operations, thereby relieving the hose of such forces.

29. Apparatus as defined in claim 28, wherein:

(a) the hose support means includes a rotatable reel for coilingly receiving the hose; and

(b) the mechanical linkage comprises a chain or cable coupled between the reel and a support means for the jet;

whereby the advance or retraction of the jet causes corresponding movement of the chain or cable, which in turn causes corresponding rotation of the reel.

STATEMENT UNDER ARTICLE 19

Claim 1 is further amended in that the jet is acknowledged to be capable of retracting as well as advancing and the other devices recited advance and retract with it, so that the characterizing clause of claim 1 is limited to the fact that the hose is advanced and retracted without applying tension or compression forces to the hose.

Claims 5 and 6 have each been modified in the penultimate line of each claim to describe the hose, when the first sprocket has the same pitch diameter as the hose, as being "fully retracted and coiled around the reel". As originally presented, the hose was not specified as being fully retracted when the diameters were compared. In a sense, the hose may lie coiled around the reel, at least to some extent, even when the hose is fully advanced, depending upon the length of the hose, the size of the reel, etc. The comparison of the pitch diameter of the first sprocket to that of the hose should be made when the hose is in fully retracted position.

The characterization of the invention in claim 1 as revised is further developed in new claim 28. Claim 28 differs from claim 1 in that it positively recites a mechanical linkage between the drive means and the hose support means that bears the forces of tension or compression associated with the advance and retraction of the jet hose and hose support means, thereby relieving the hose of such forces. No specific recital of any such mechanical linkage was made in claim 1, and it was thought desirable that at least one independent claim in the application should so provide.

Claim 29 is a new claim dependent upon claim 28 that further characterizes the mechanical linkage in the context of an appratus in which the hose support means includes a rotatable reel for coilingly receiving the hose.

Whilst claim 3 indicates that the chain may be coupled between the jet and reel, actually in the preferred embodiment, the chain is coupled between the base of the nozzle apparatus which could be construed as a support means for the jet, and thus this terminology has been presented in claim 29. However, the difference between claim 29 and claim 3 in this respect appears

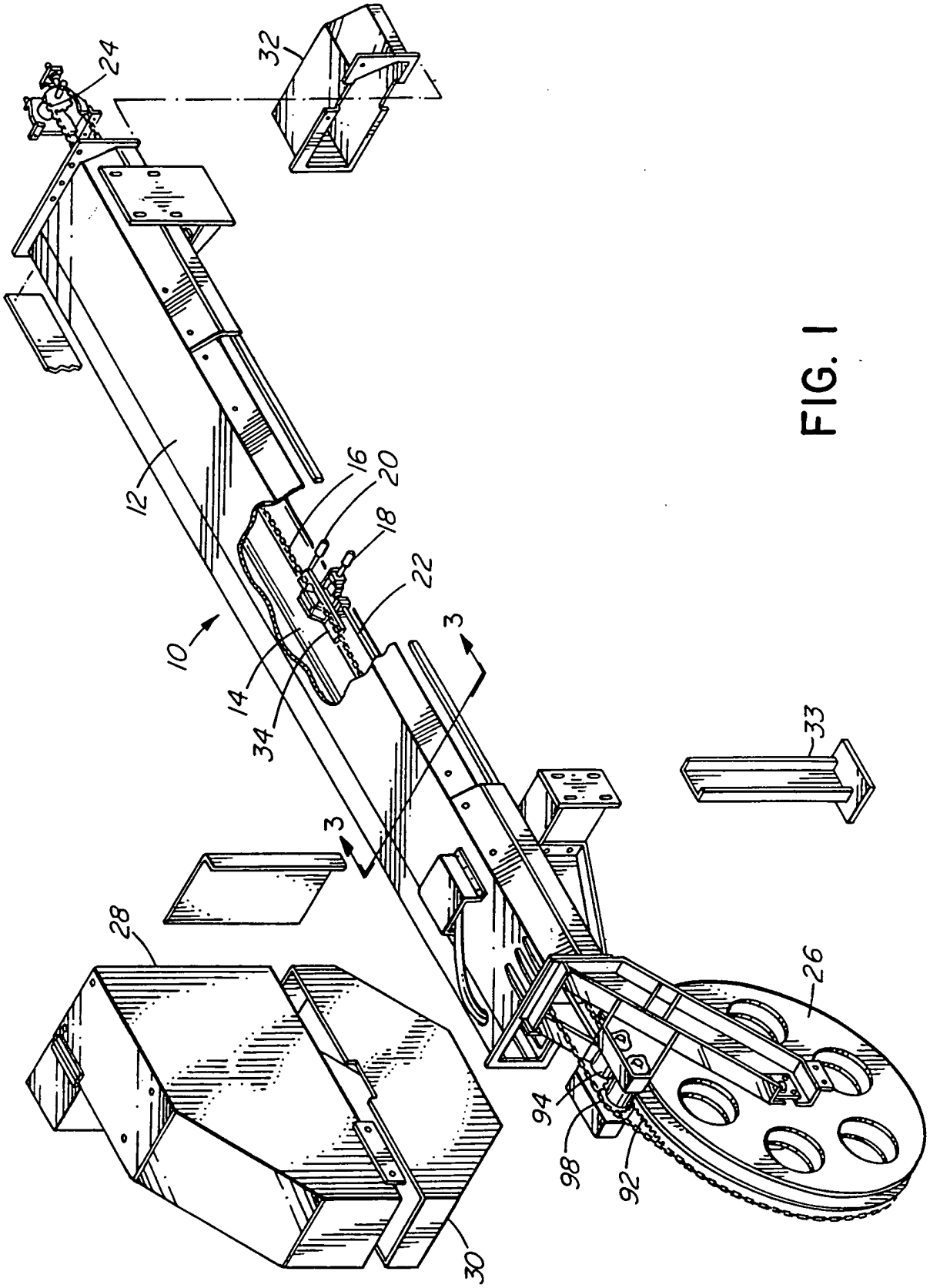

FIG. 1

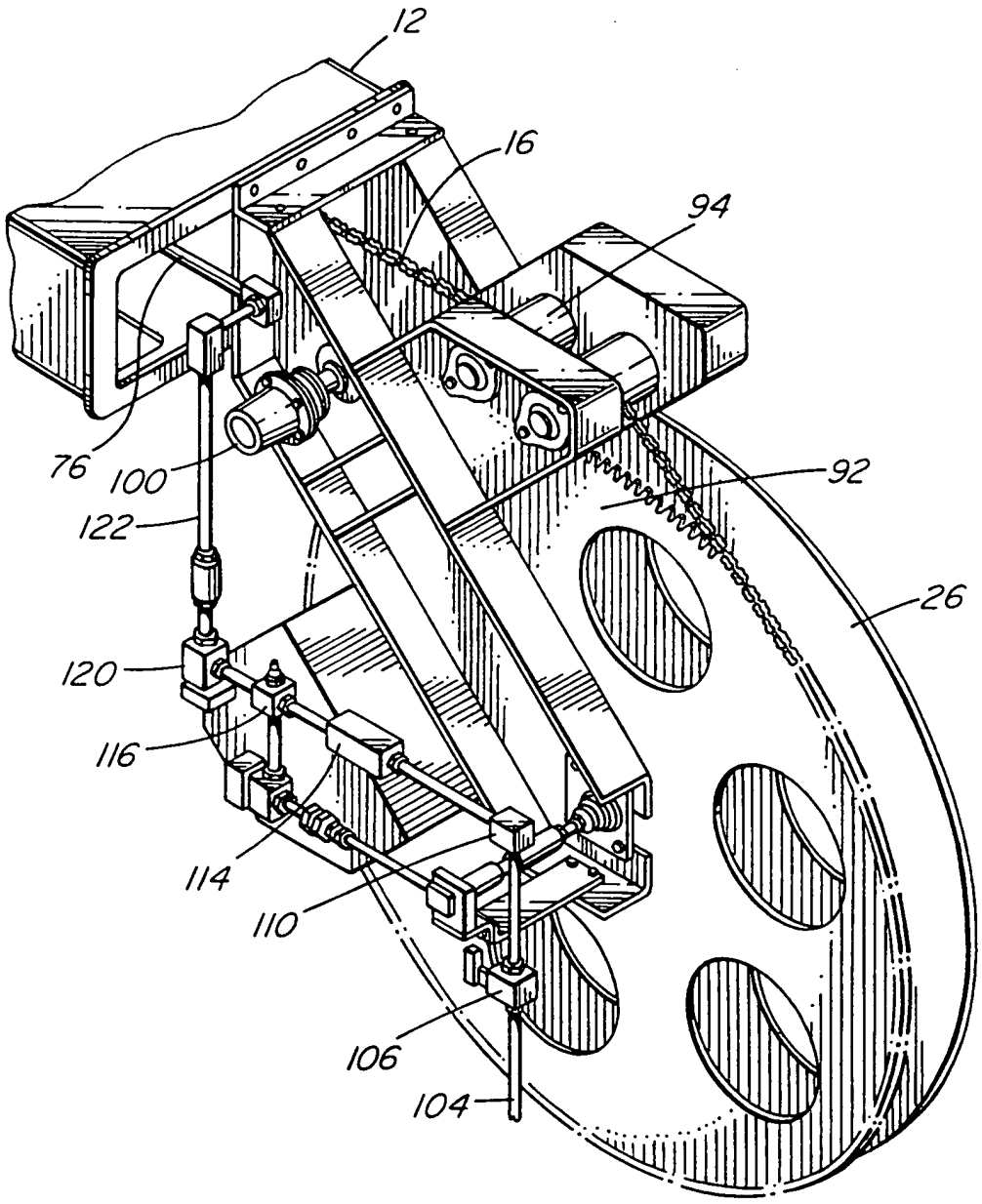

FIG. 2

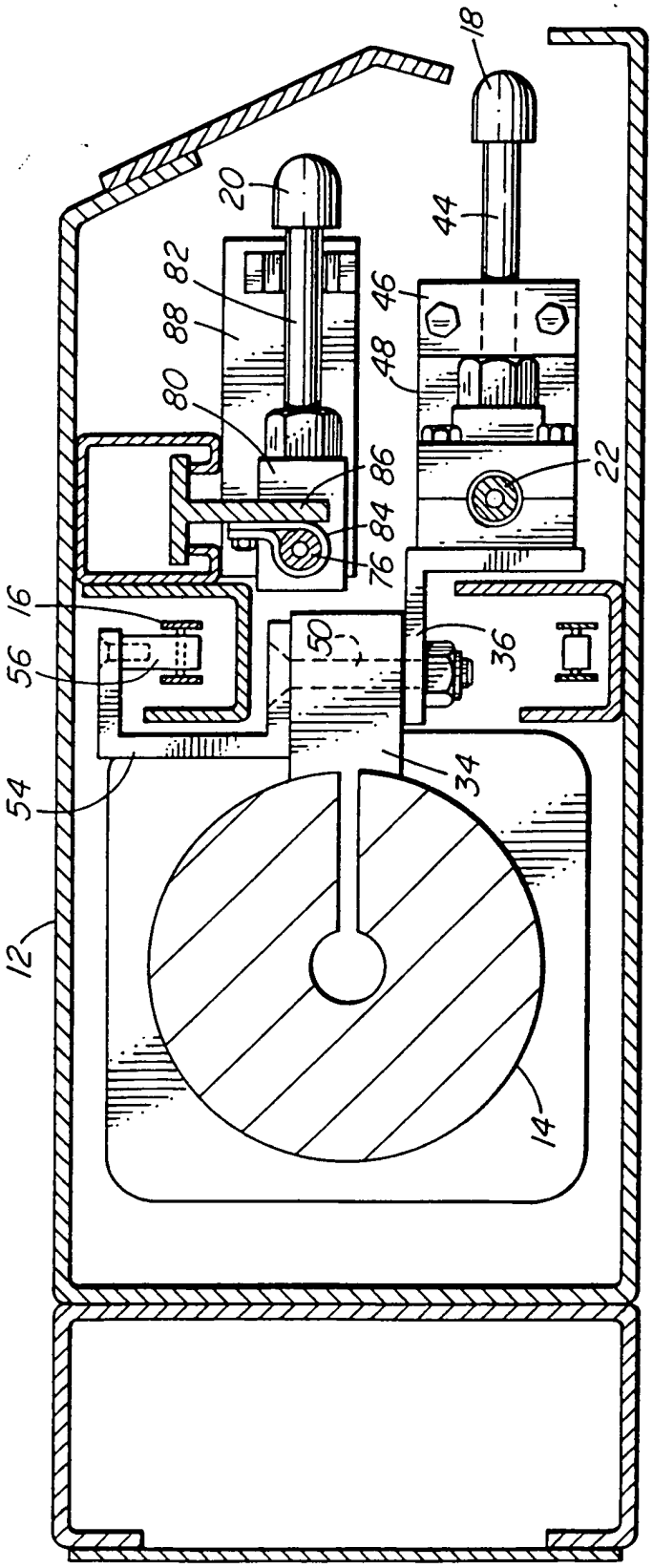

FIG. 3

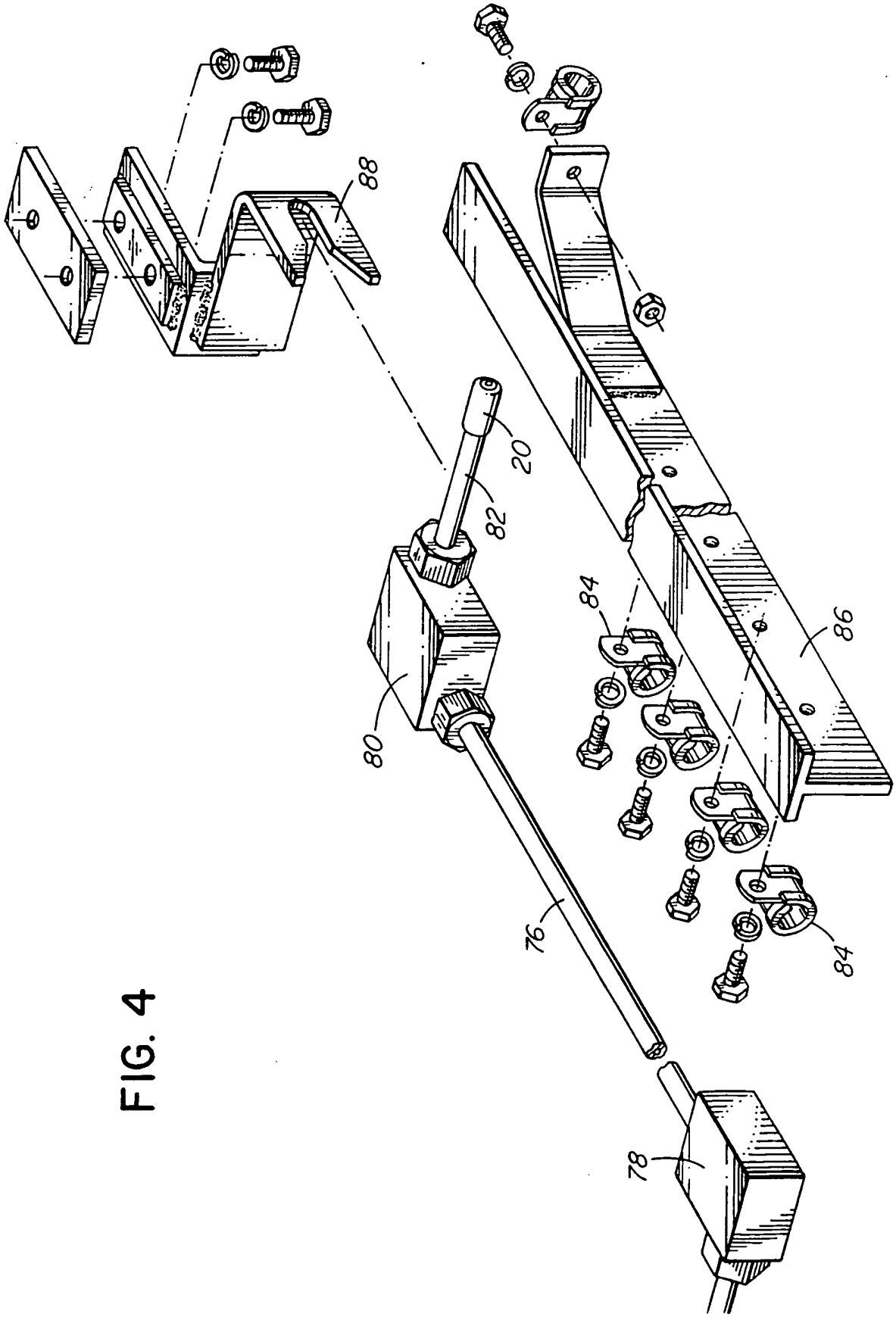

FIG. 4

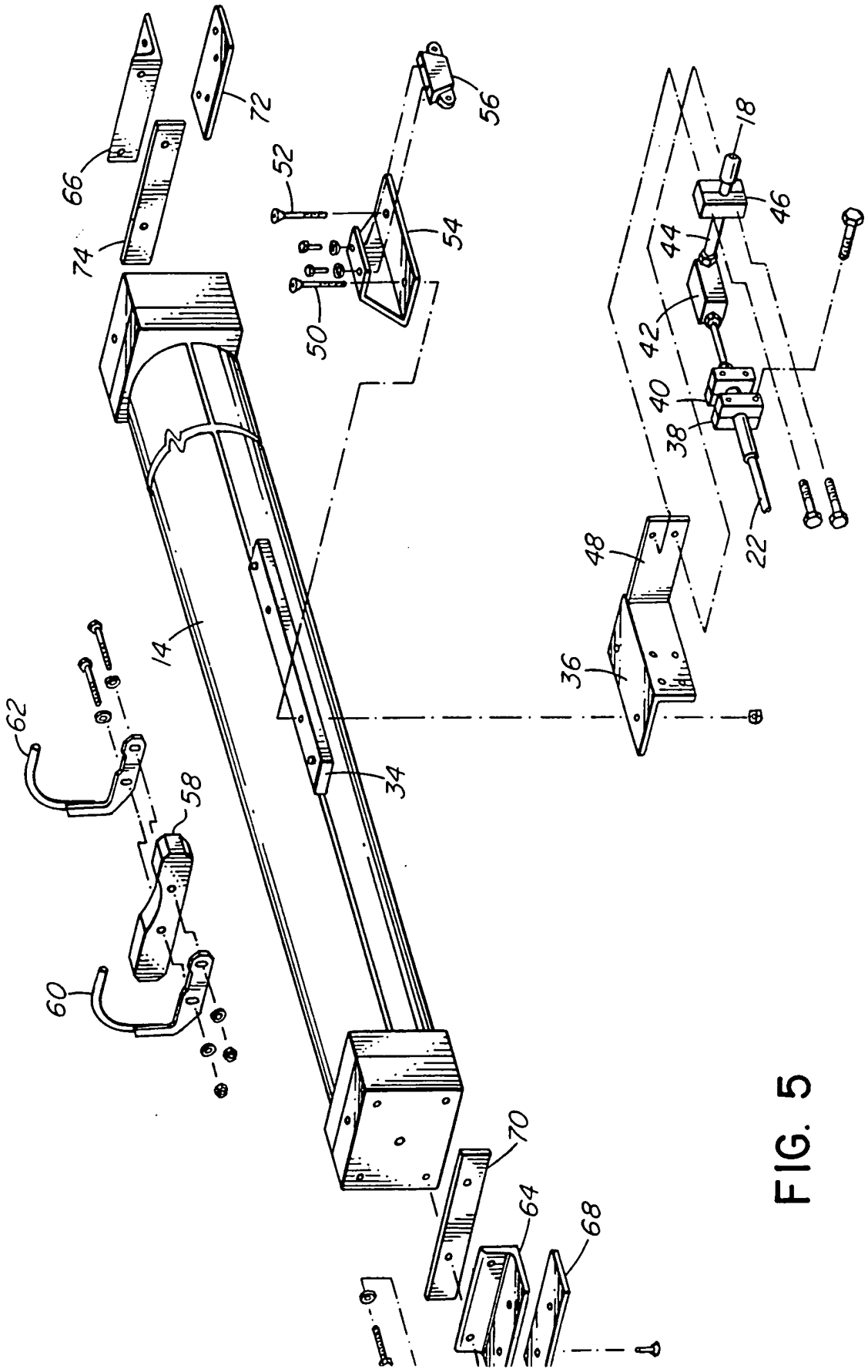

FIG. 5

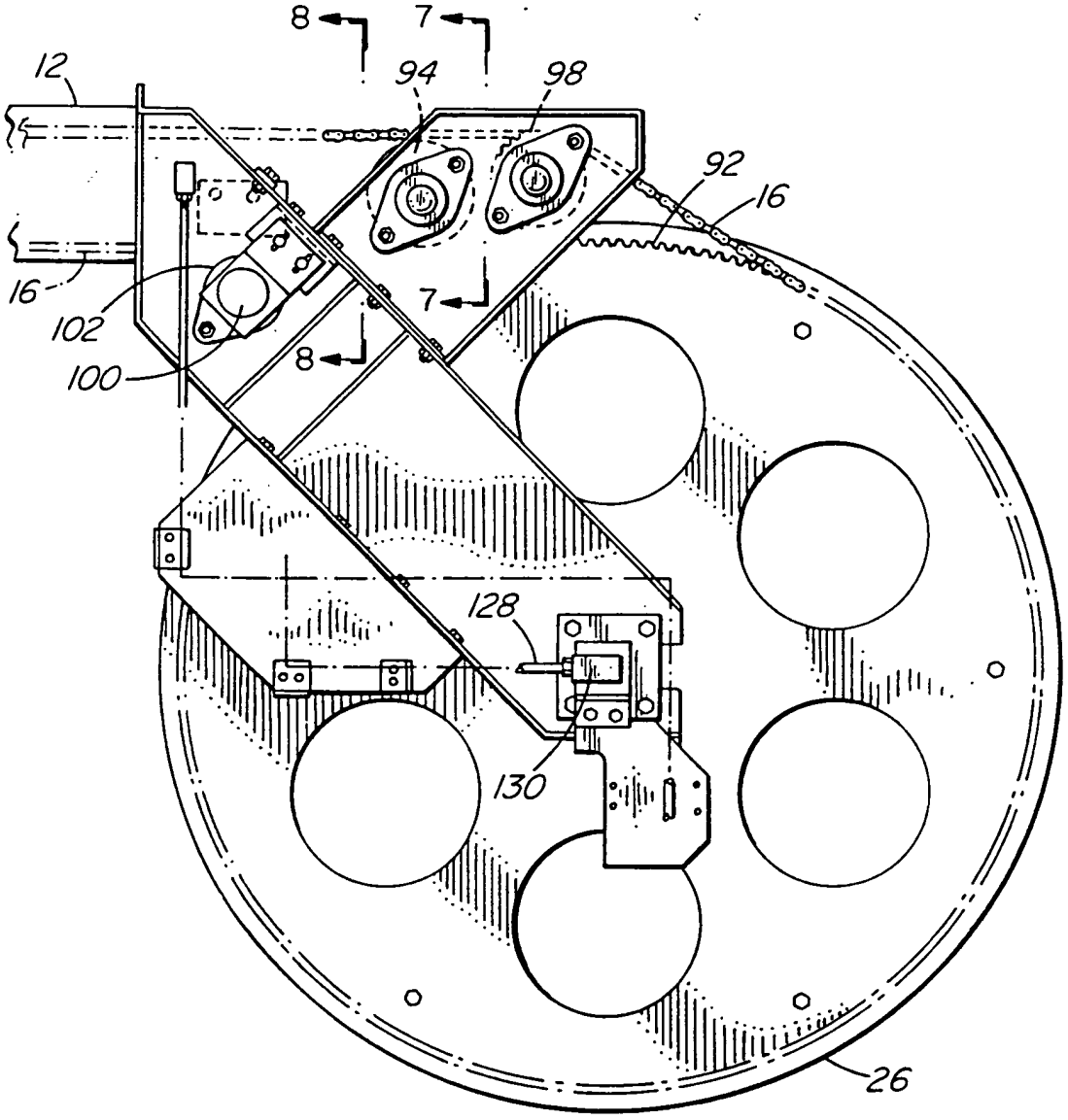

FIG. 6

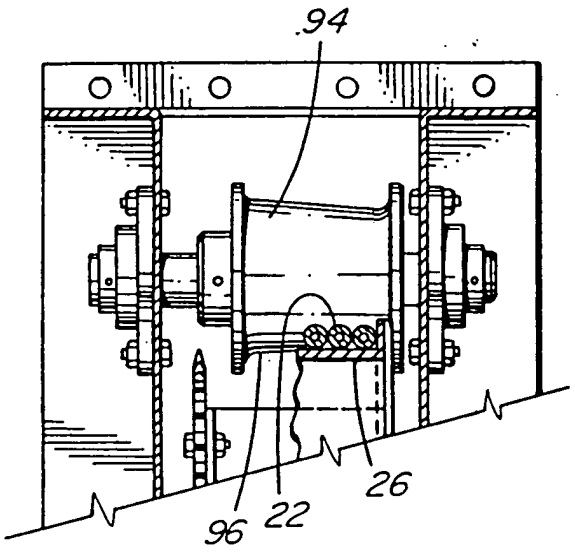

FIG. 7

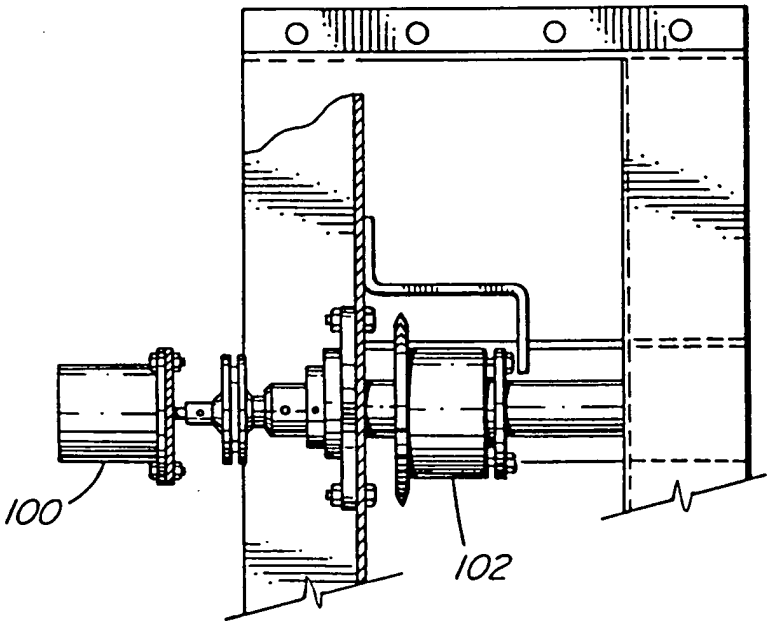

FIG. 8

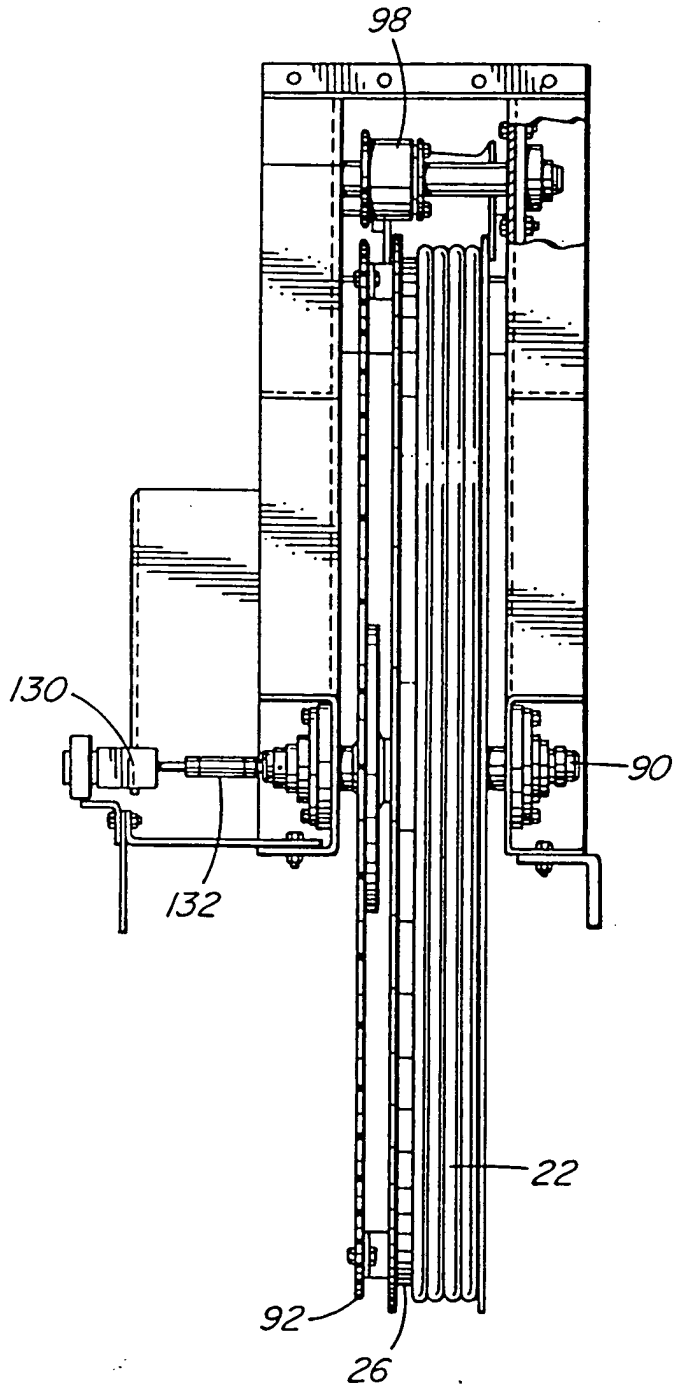

FIG. 9

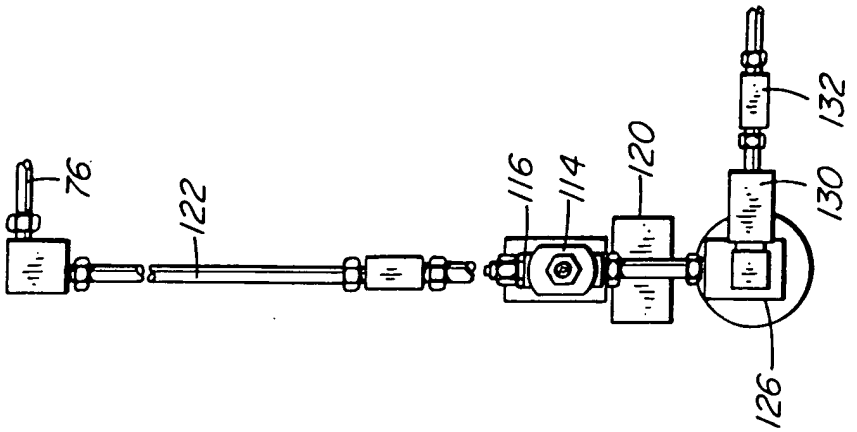
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FIG. 11

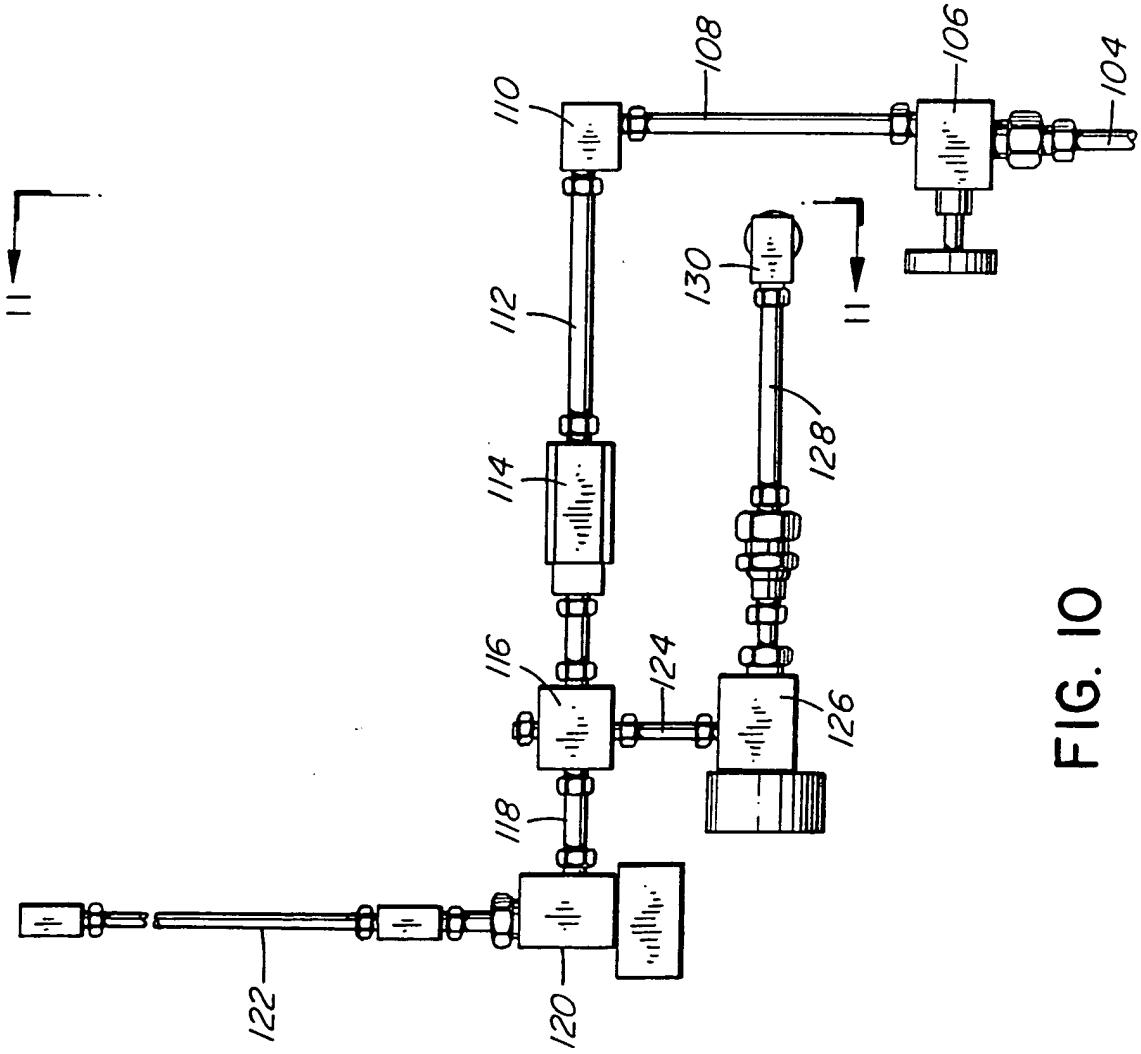
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FIG. 10

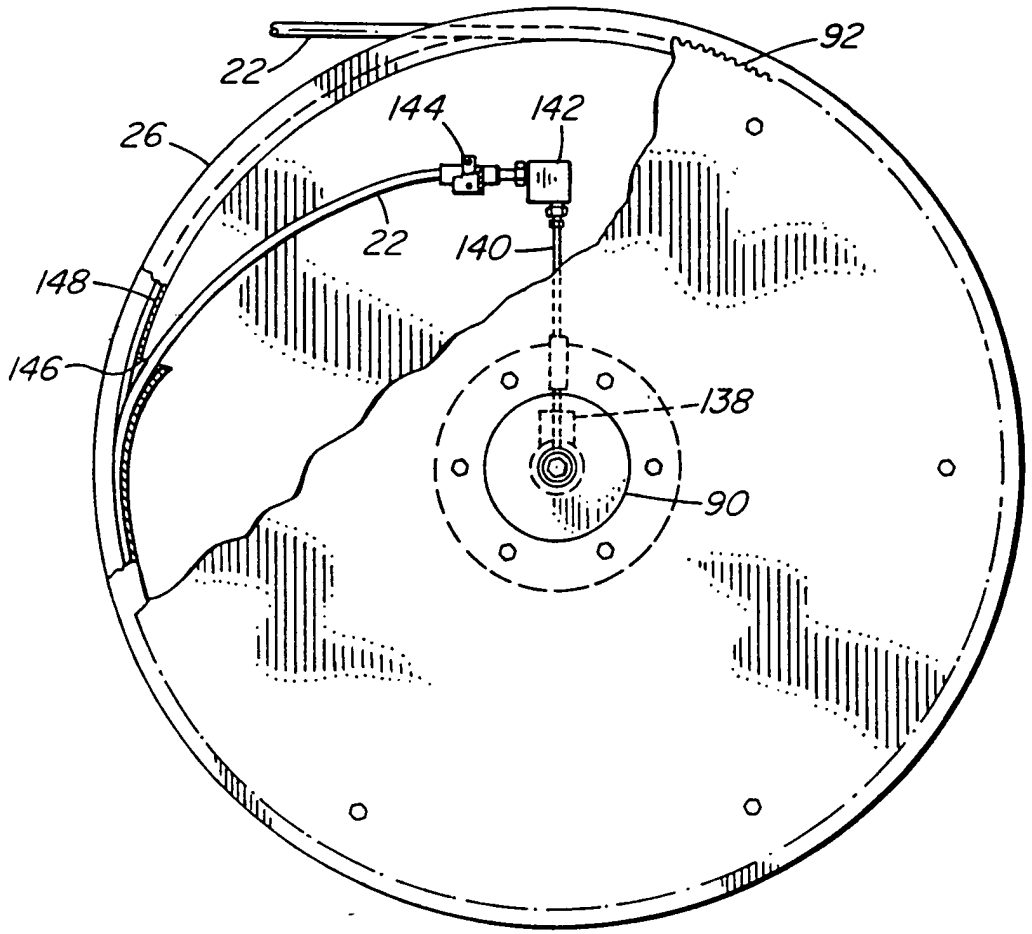

FIG. 12

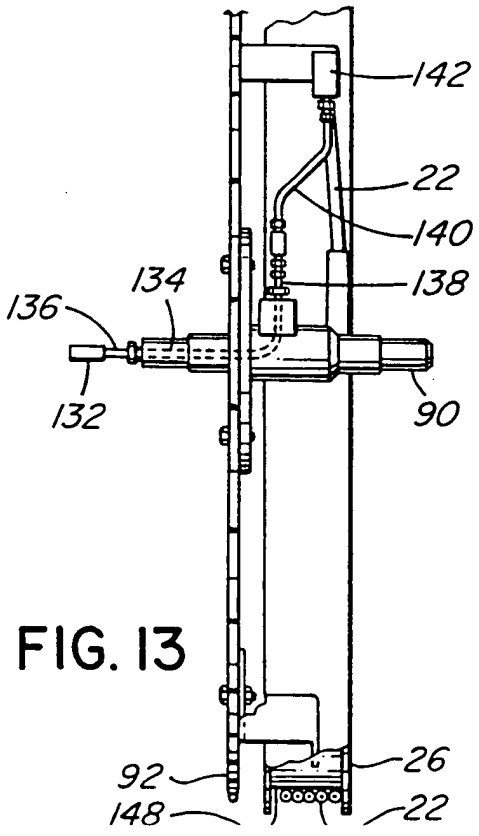

FIG. 13

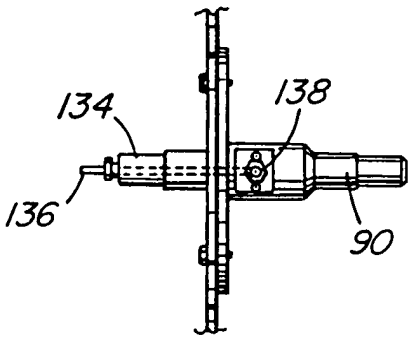

FIG. 14

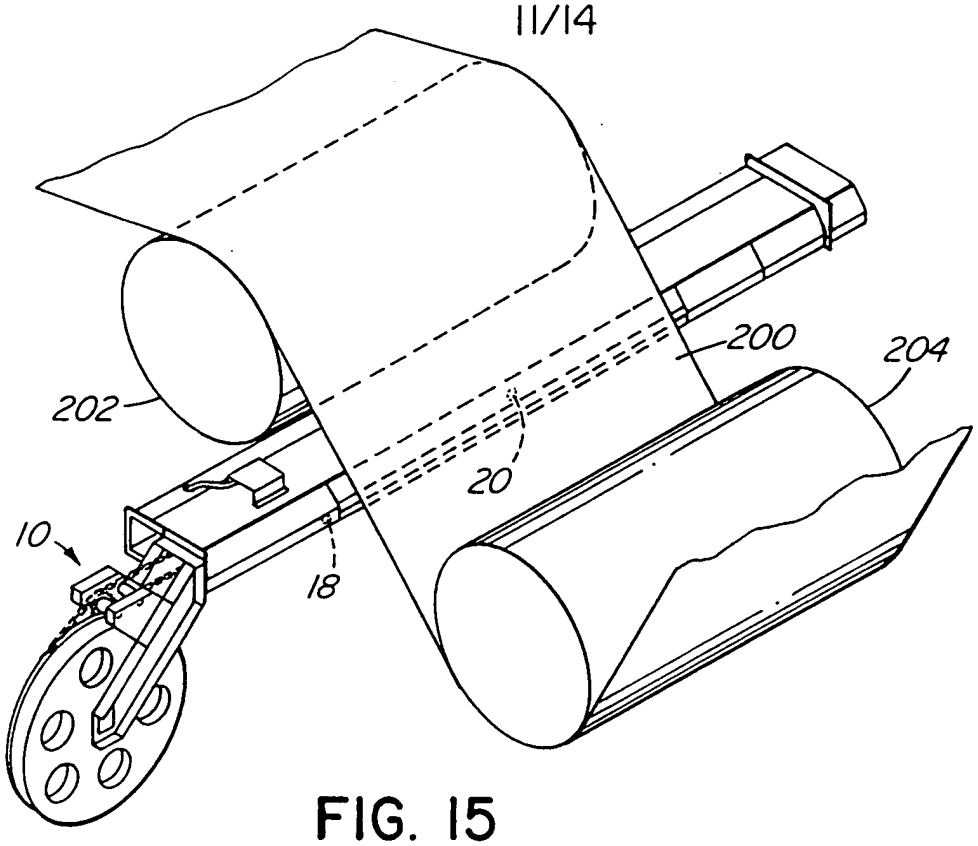

FIG. 15

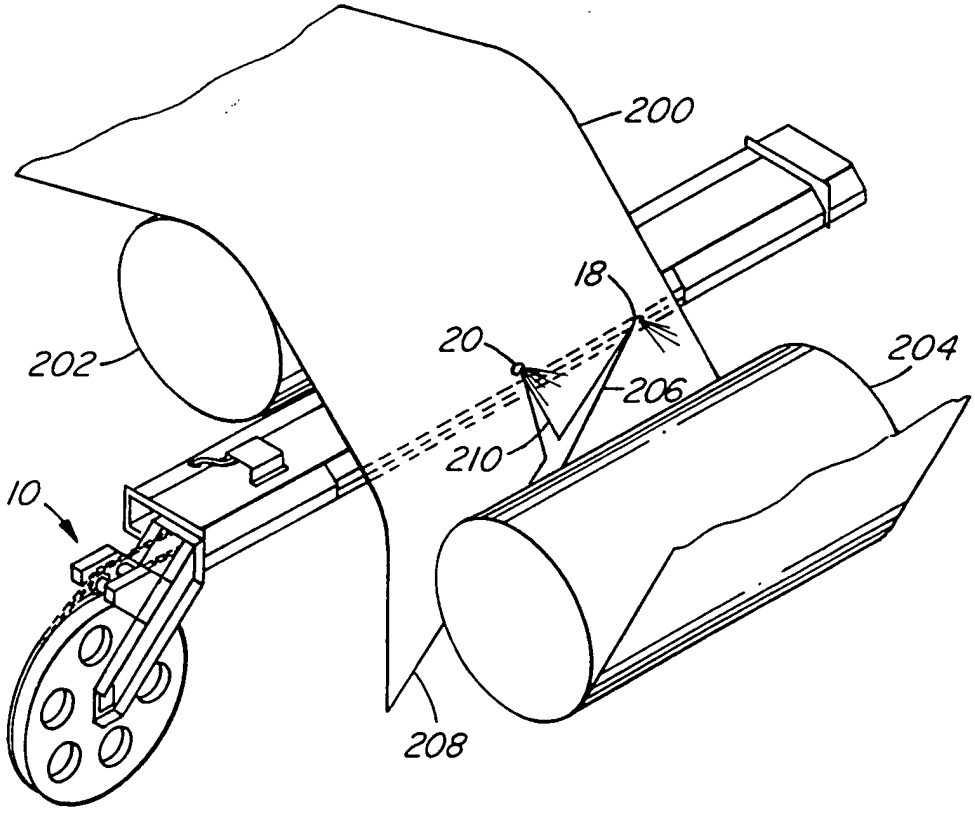

FIG. 16

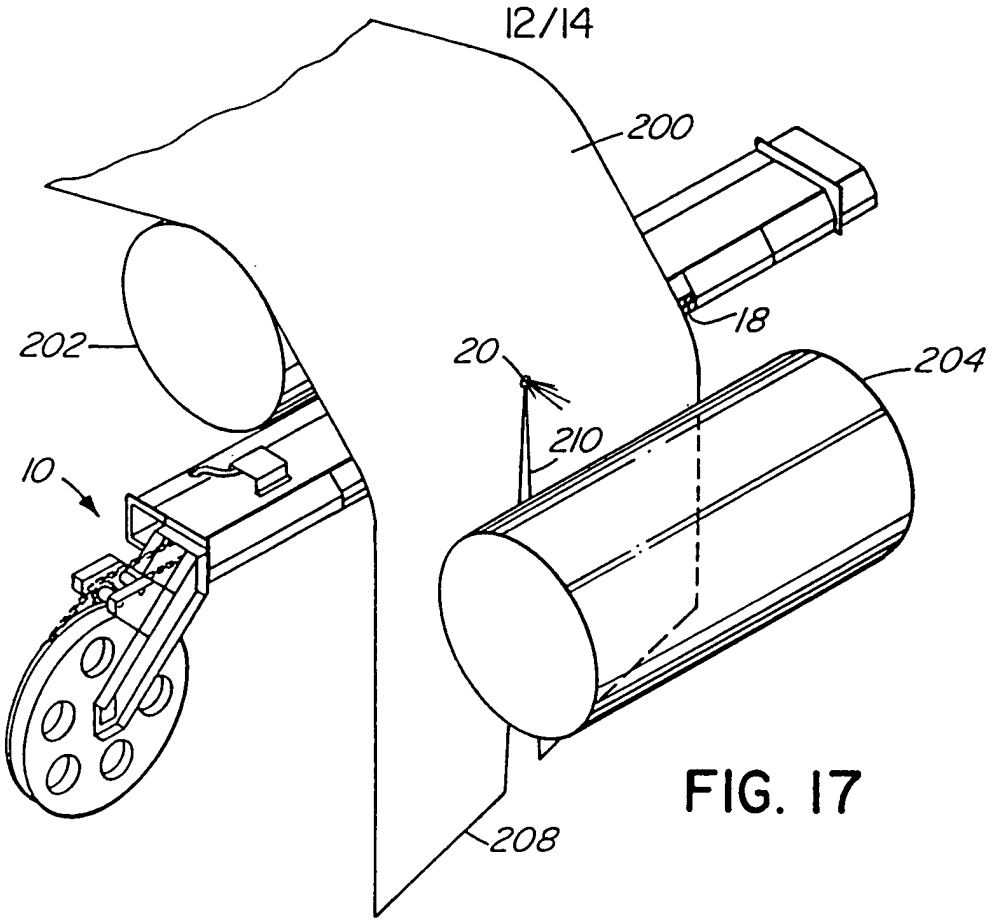

FIG. 17

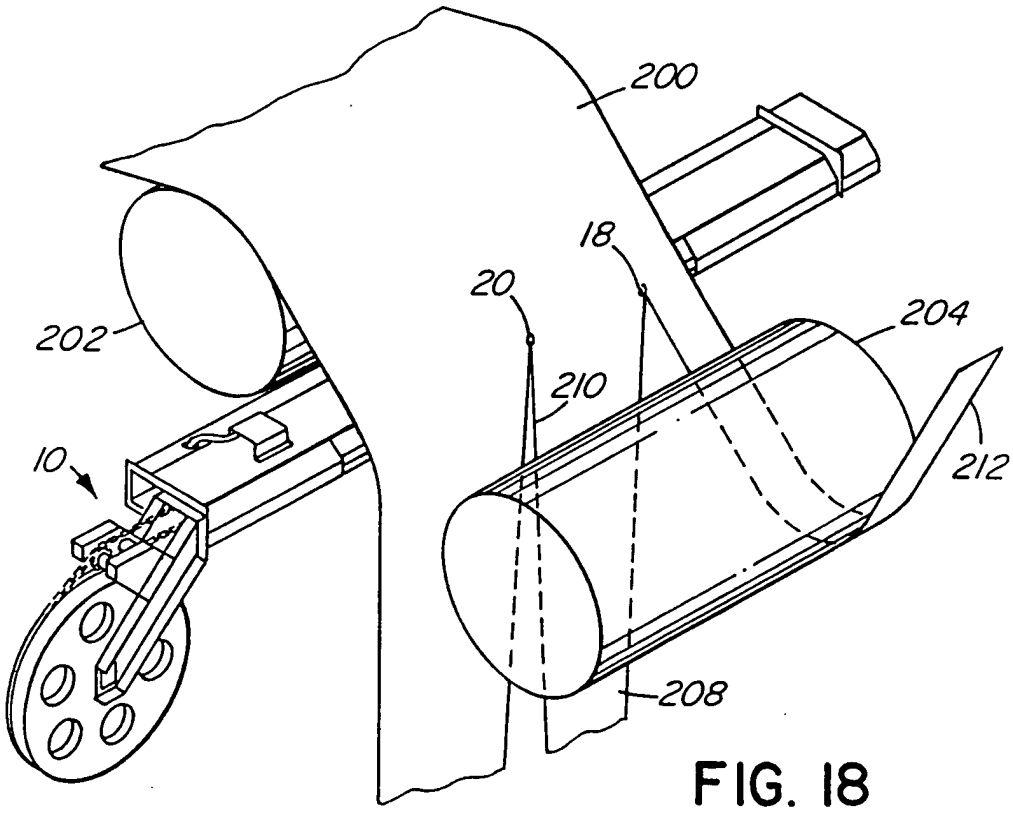

FIG. 18

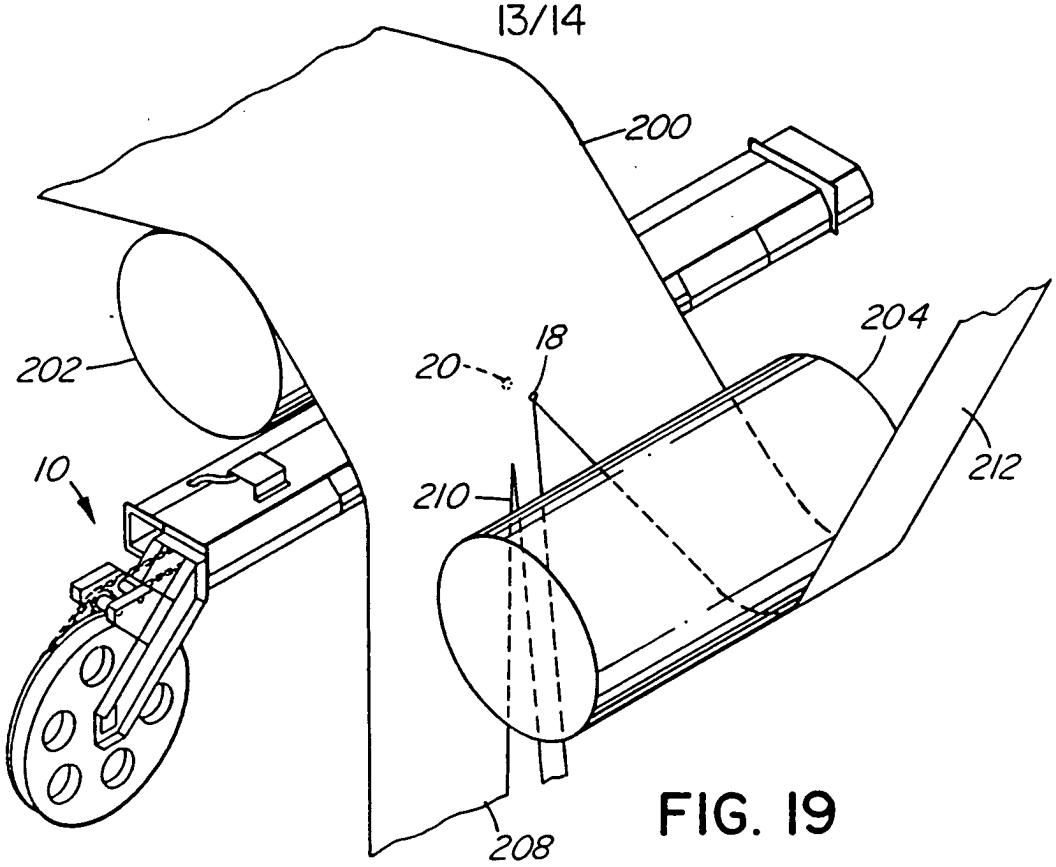

FIG. 19

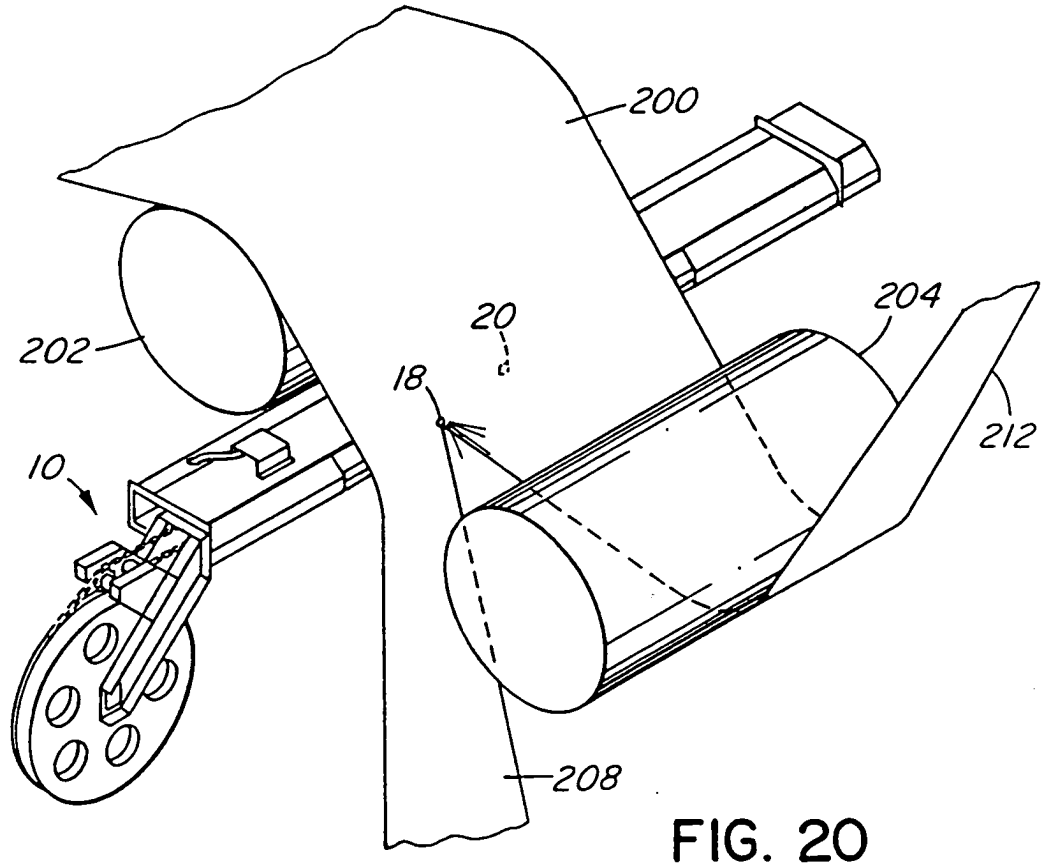

FIG. 20

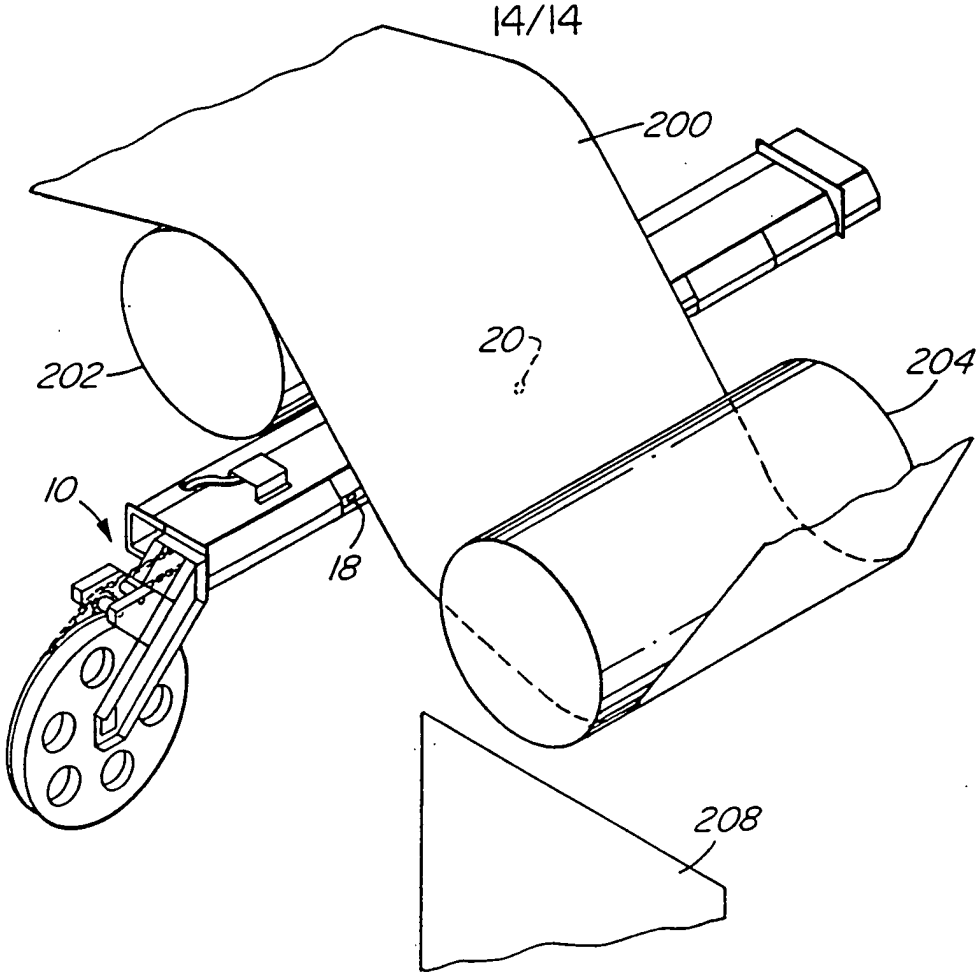

FIG. 21

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 2006499 (C.A. FOURNESS ET AL) 2 July 1935, see the whole document	1,2
A	US, A, 1858131 (G.W. BICKING) 10 May 1932, see the whole document	1,2
A	US, A, 4007652 (SHINOMIYA ET AL) 15 February 1977, see the whole document	1,2
A	DE, A5, 1070017 (J.M. VOITH G.M.B.H) 26 November 1959, see the whole document	1,2
A	DE, C, 1293563 (J.M. VOITH G.M.B.H.) 8 January 1970, see the whole document	1,2

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 90/00255

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: B 26 F 3/00, D 21 F 1/34 // B 26 F 1/26, D 21 G 9/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	B 26 F; D 21 F; D 21 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US, A, 3625813 (BERNARD C. ECKELMAN) 7 December 1971, see the whole document	1,2,4, 13,15
A	--	3,8,14, 16,17
A	US, A, 4343211 (VOLLE) 10 August 1982, see the whole document	1-4,13, 15-17
A	--	
A	US, A, 3088355 (L. HORNBOSTEL, JR) 7 May 1963, see the whole document	1-4,6, 15
	--	

* Special categories of cited documents: [10]

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5th November 1990	21 NOV. 1990
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	MISS T. TAZELAAR

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/CA 90/00255

SA 39115

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 27/09/90
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 3625813	07/12/71	NONE		
US-A- 4343211	10/08/82	CA-A-	1151523	09/08/83
		DE-A-C-	3044716	19/06/81
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US-A- 2006499	02/07/35	NONE		
US-A- 1858131	10/05/32	NONE		
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